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AN EARLY SINGLE TREE APPLICATION FOR DOUGLAS-FIR FOLIAGE AND CONE PROTECTION FROM THE WESTERN SPRUCE BUDWORM

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TITLE

AN EARLY SINGLE TREE APPLICATION FOR DOUGLAS-FIR FOLIAGE AND CONE PROTECTION FROM THE WESTERN SPRUCE BUDWORM

BY

Lawrence E. Stipe and John S. Hard

ABSTRACT

An early ground application of acephate and carbaryl for Douglas-fir foliage and cone protection was conducted at Lubrecht Experimental Forest, Montana, during 1979. Thirty cone-bearing trees were selected and randomly assigned one of three treatments (acephate, carbaryl, check). Both materials were applied when the expanding female conelets were approximately 1 inch long. Each material was mixed according to label instructions and applied with a hydraulic sprayer. Foliage protection was 85.2 percent for acephate and 93.9 percent for carbaryl. Total seed production averaged 4.8 seeds per cone for acephate, 12.6 for carbaryl, and 0 for the checks. Number of good seed produced per cone was 0.51 for acephate, 1.01 for carbaryl, and 0 for the checks.

INTRODUCTION

In recent years the management of forest reproductive systems has become increasingly more dependent on site-specific seed production as a source of nursery stock. Recent National Forest management regulations, plus a revived commitment to reduce the reforestation backlog, have accelerated and given renewed importance to localized seed production. Of concern is seed production requirements stratified by habitat type, elevation, and seed zone. Forest managers in the Northern Region have designated and are managing many stands specifically for seed production. These seed production areas were carefully selected to fulfill specific needs and have been cultured for optimum seed production. Seed yield from many of these areas has been seriously reduced or at

times entirely eliminated through cone and seed damage caused by the western spruce budworm (Dewey 1970; Dewey and Jenkins 1979). Seed loss may also occur indirectly during prolonged budworm outbreaks when repeated defoliation causes top-kill and branch mortality (Bousfield and Williams 1977). Not only are techniques needed to protect the current seed crop but also to prevent crown damage. This project was designed around the early application of two insecticides registered for budworm control. This report describes procedures and sampling techniques used to evaluate an early treatment of Orthene Forest Spray® (acephate) and Sevimol 4® (carbaryl).

OBJECTIVE

The objective of this project was to evaluate the effectiveness of protecting new foliage and cones of Douglas-fir against second and third instar spruce budworm larvae with an early ground application of acephate and carbaryl.

PROJECT AREA

This project was conducted in an open-grown Douglas-fir stand located near Coyote Park on Lubrecht Experimental Forest, University of Montana, Missoula. This site had a satisfactory combination of trees with a large number of reproductive buds, general tree condition and size, and moderate to heavy budworm population.

ADMINISTRATION AND FUNDING

Personnel from Forest Insect and Disease Management (FI&DM), State and Private Forestry, Northern Region, administered this project. Overall coordination and supervision was the responsibility of the Canada/U.S. (CANUSA) spruce budworm specialist assigned to FI&DM. FI&DM laboratory facilities and crew processed larval, cone, seed, and defoliation samples. X-ray equipment at

the Forestry Sciences Laboratory, University of Montana, was used for seed examination. Funding was provided through the budget allotment to FI&DM from the CANUSA Program.

INSECTICIDES

Orthene Forest Spray (O,S-Dimethylacetylophosphoramidothioate) is an organophosphate insecticide of moderate persistence and is primarily a contact and stomach poison with some residual systemic action. Formulation is 75 percent active ingredient (AI) by weight. Sevimol 4 (1-naphthylmethylcarbamate) is a widely used forest and agricultural spray of moderate persistence. It is a broad spectrum poison and is a molasses formulation of carbaryl at 4 pounds AI per gallon.

APPLICATION

Application timing was based on budworm larval stage II dispersal data provided by David G. Fellin, Forestry Sciences Laboratory, Missoula, Montana (appendix 1). Both insecticides were applied during the early morning hours on May 21, 1979, with a hydraulic pumper operated at 400 pounds per square inch. Between applications, spray equipment was cleaned and rinsed with Nutra-Sol®. The following tank mixes were used:

Acephate: 2/3 lb. (1/2 lb. AI) in 100 gallons water

Carbaryl: 2 qts. (2 lbs. AI) in 100 gallons water

These mixtures were applied at 5 to 6 gallons per tree, which was just beyond the point of runoff. Normal insecticide safety precautions were followed during storage, handling, mixing, and application.

DESIGN AND SAMPLING

Sample trees were open-grown Douglas-fir ranging from 30 to 60 feet in height and separated by at least 1 chain. Each tree was numbered and randomly assigned one of three treatments (acephate, carbaryl, check). This design provided 10 single tree replications for each of the three treatments.

Prespray population samples were collected on May 19, 1979, followed by postspray collections on May 24 (3-day) and June 4 (14-day). For each collection two upper-crown branches (18 inches) were cut plus additional cones to provide at least 10 cones per tree per sample period (appendix 4). Laboratory data were recorded as following:

1. Number of vegetative buds per branch.

2. Number of cones or buds by one of the following damage classes:

   a. Dead bud - female reproductive buds that did not open, cause unknown.

   b. Infested dead - fully expanded cone bud with extensive internal tissue damage (figure 1).

   c. Infested green - fully expanded cone with superficial feeding damage but with the cone axis apparently undamaged (figure 1).

   d. Uninfested green cones with no apparent damage or feeding.

3. Number of live and dead larvae in each cone.

4. Separate larvae by instar on prespray and 14-day postspray samples.

Robert D. Oakes

Figure 1. Cross section of an infested green (left) and infested dead (right) cone from the 3-day postspray sample.

Three additional postspray samples were collected to evaluate long-term effects of each treatment.

Mature larval population - July 5 and 10.

Postfeeding defoliation - July 19 and 20.

Mature cones - August 23.

Mature larval samples consisted of two midcrown branches (18 inches) cut when larvae were in the 4th, 5th, and 6th instar. Following completion of larval feeding, two 18-inch branches were removed from each sample tree and

25 new shoots per branch were rated for defoliation using the following six-class system.

Defoliation Class	Percent Defoliation
0	0
1	1-25
2	26-50
3	51-75
4	76-99
5	100

Mature cone samples were collected prior to seed release. Cones were rated for external damage based on excessive resin exudation, distorted shape (curvature), and evidence of insect feeding. Damage was visually classified and recorded using a damage rating system developed by Dewey and Jenkins, 1979.

Damage Class	Percent Damage
1	0
2	1- 10
3	11- 25
4	26- 50
5	51- 75
6	76-100

Following a short air drying period, seeds were extracted and X-rayed.

RESULTS

Larval development recorded from head capsule measurements for the prespray and 14-day postspray samples is summarized below:

Prespray - 2nd instar 100 percent

14-day postspray - 2nd instar 21 percent
3rd instar 74 percent
4th instar 5 percent

Population reduction and amount of foliage saved were the most striking and promising results of this project. Both were well above what was expected. Table 1 shows budworm larval populations per 100 new shoots by sample tree and treatment near the end of larval development.

Table 1.--Mature larval population density per 100 new shoots by tree number and treatment

Tree #	Treatment		
	Acephate	Carbaryl	Check
1	4.8	0.2	11.7
2	0	1.5	33.7
3	15.3	0	19.8
4	2.8	0	10.6
5	*	3.4	26.5
6	1.5	*	*
7	.4	4.8	28.3
8	2.0	1.1	17.9
9	*	0	*
10	2.2	.3	*
Mean	3.6	1.3	21.2
% Reduction	83.0	93.9	

* No sample collected

Because a conventional prespray population sample per 100 shoots was not possible, the number of prespray larvae per cone was used as the prespray population index. The number of larvae per cone was used as a subsample of the prespray population per 100 shoots. We assumed that the prespray population means per 100 shoots were the

same (appendix 2), and percent population reduction was based on the mature larval population differences between acephate and carbaryl in relation to the check trees. This computation gave the following results:

Treatment	Percent Population Reduction
Acephate	83.0
Carbaryl	93.9

During late larval development, light defoliation on treated trees showed a striking contrast when compared to the heavy defoliation on the adjacent untreated trees. Defoliation data tallied by tree in table 2 validate our field observations.

Table 2.--Percent defoliation following pupation by tree number and treatment

	Treatment		
Tree #	Acephate	Carbaryl	Check
1	2.7	0.8	58.8
2	4.5	.8	74.0
3	38.0	.5	82.3
4	7.5	2.0	69.3
5	6.8	.3	55.3
6	6.3	5.8	50.8
7	1.3	1.0	63.3
8	3.0	1.8	97.5
9	27.3	.8	80.0
10	10.5	7.8	99.0
Mean	10.8	2.2	73.0
Protection %	85.2	97.0	

Foliage protection was well above the 10-30 percent generally recorded during aerial projects in the Northwest (Flavell et al. 1977, 1978; and Stipe et al. 1977). Aerial applications are typically conducted during the late instar period when prespray defoliation is well over 50 percent. Our treatments were applied approximately 20 days before vegetative bud burst, thus eliminating any prespray damage to the new shoots. Following bud burst a small residual budworm population caused 10.8 percent defoliation on trees treated with acephate and 2.2 percent for carbaryl sprayed trees. This represents 85.2 and 97.0 percent foliage protection when compared to the 73.0 percent defoliation recorded on the check trees. Good population reduction and foliage protection were obtained even though treated trees stood among untreated trees with a high budworm population.

The number of prespray larvae per cone for each treatment was approximately 1 and increased on the 3-day sample to a high of 8.2 (appendix 2). This increase and the increase in other population indices during the peak dispersal period reveal the large migration of small larvae onto the foliage and cones (appendix 1). The number of larvae per cone on the treated trees was well below numbers on check trees at the 3-day sample. For the 3-day postspray acephate and carbaryl continued to kill dispersing larvae as they moved into the small cones. Beyond the 3-day sample the larval population per cone declined in all treatments except budworm population density, for the checks remained above those for acephate and carbaryl (appendix 2).

Budworm damage to expanding cones occurred very early in bud development causing many cones to abort (figure 2). Prespray sample data show from 20 to nearly 40 percent of the young cones infested with budworm: furthermore, most of these later aborted and fell to the ground (appendices 3 and 5). The number of green uninfested cones decreased sharply at 3 days, showing again that dispersing larvae were moving into the newly expanded cones. At 14 days only 1.1 percent of the check tree cones remained uninfested, whereas 22.0 percent of the

acephate and 41.6 percent of the carbaryl sprayed cones were still budworm free.

Jerald E. Dewey

Figure 2. Budworm killed cones (above branch) and undamaged cones (below branch) at time of vegetative bud swell.

Mature cone samples were collected when cone development was nearly complete, but before seed drop. Unfortunately, squirrels had already begun cone harvest. The majority of this sample consisted of partially damaged cones and those that had aborted earlier but remained on the tree. Green undamaged cones were rare. Appendix 6 summarizes the visual damage ratings from the mature cone sample. Although the relationship between visual damage and seed production is not known, these data appear to be fairly consistent.

Total seed production per cone from acephate sprayed trees was 4.8, and 12.6 for carbaryl (appendix 6).

The results of the seed X-ray analysis in percent are as follows:

Treatment	Full	Hollow	Seed Chalcid	Total # Seed
Acephate	10.6	82.7	6.7	1,209
Carbaryl	8.0	80.4	11.6	4,871
Check	----------No Seed----------			

No apparent damage other than budworm-caused damage occurred before June 4 (14 days). Although budworm continued to feed through early July, much of the damage caused during the later stages of cone development was caused by other seed and cone insects. Our sampling techniques were not designed to qualify or quantify cone damage beyond the 14-day sample. Except for the Douglas-fir seed chalcid found during seed X-raying, those insects responsible for damage after the 14-day sample are not known.

The number of good seed produced per cone was 0.51 for acephate, 1.01 for carbaryl, and 0 for the checks.

CONCLUSIONS AND RECOMMENDATIONS

These data clearly indicate that if the primary goal is foliage protection, a single ground application following cone burst would be very effective. However, when cone and seed production is important, a single treatment will provide only moderate cone protection and a small increase in good seed yield. Higher than expected cone and seed damage was primarily the result of two factors; (1) nearly 30 percent cone loss before treatment, and (2) subsequent damage by other insects.

Moderate residual insecticides like acephate and carbaryl applied once during early cone development will, at best, increase seed production only a small amount.

For chemicals of these types to be effective in protecting cones, more than one application is needed. We recommended that a multiple-application project be conducted with initial treatment applied when cones begin to expand. A multiple application would lengthen the effective period of cone protection and minimize prespray loss. Additional development is needed before acephate or carbaryl can be recommended for single-tree cone protection. Until then land managers will face continued difficulty meeting Douglas-fir seed production goals during budworm outbreaks.

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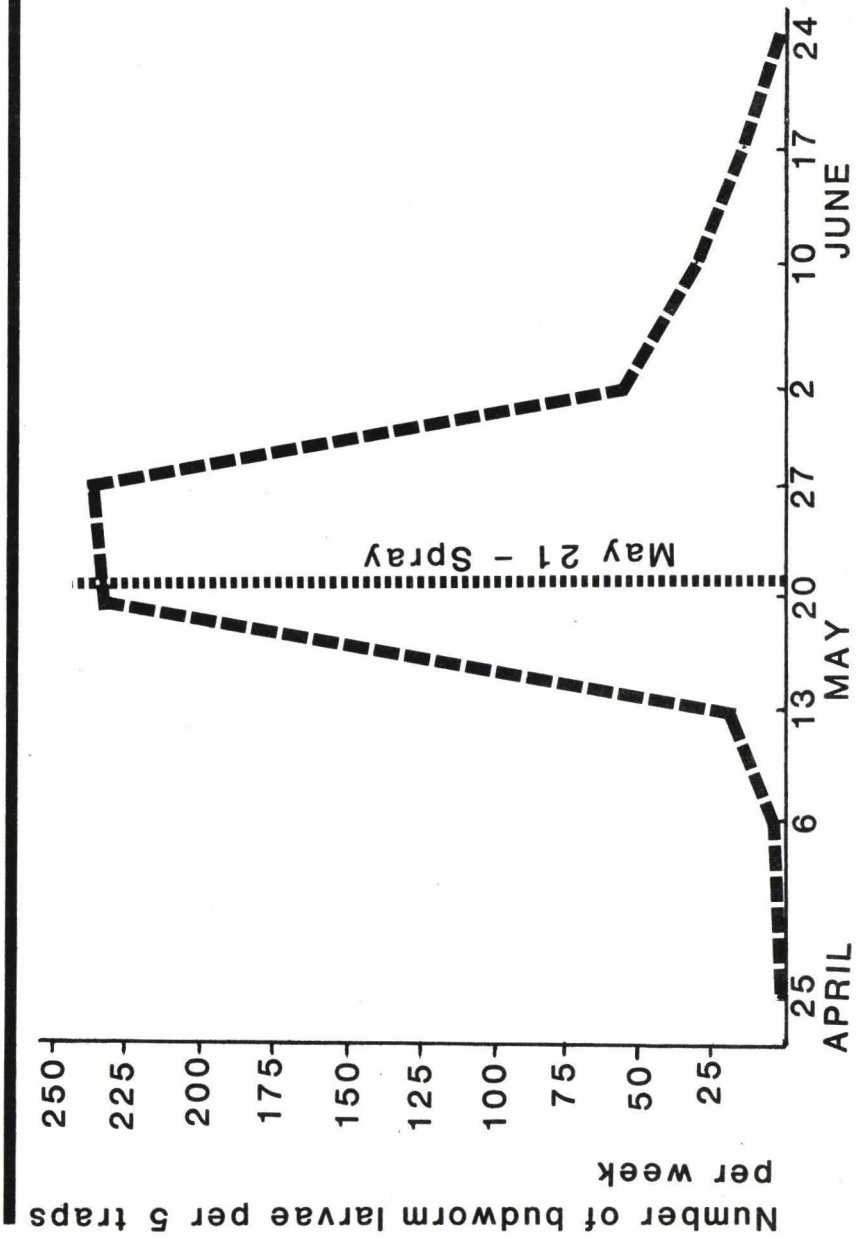
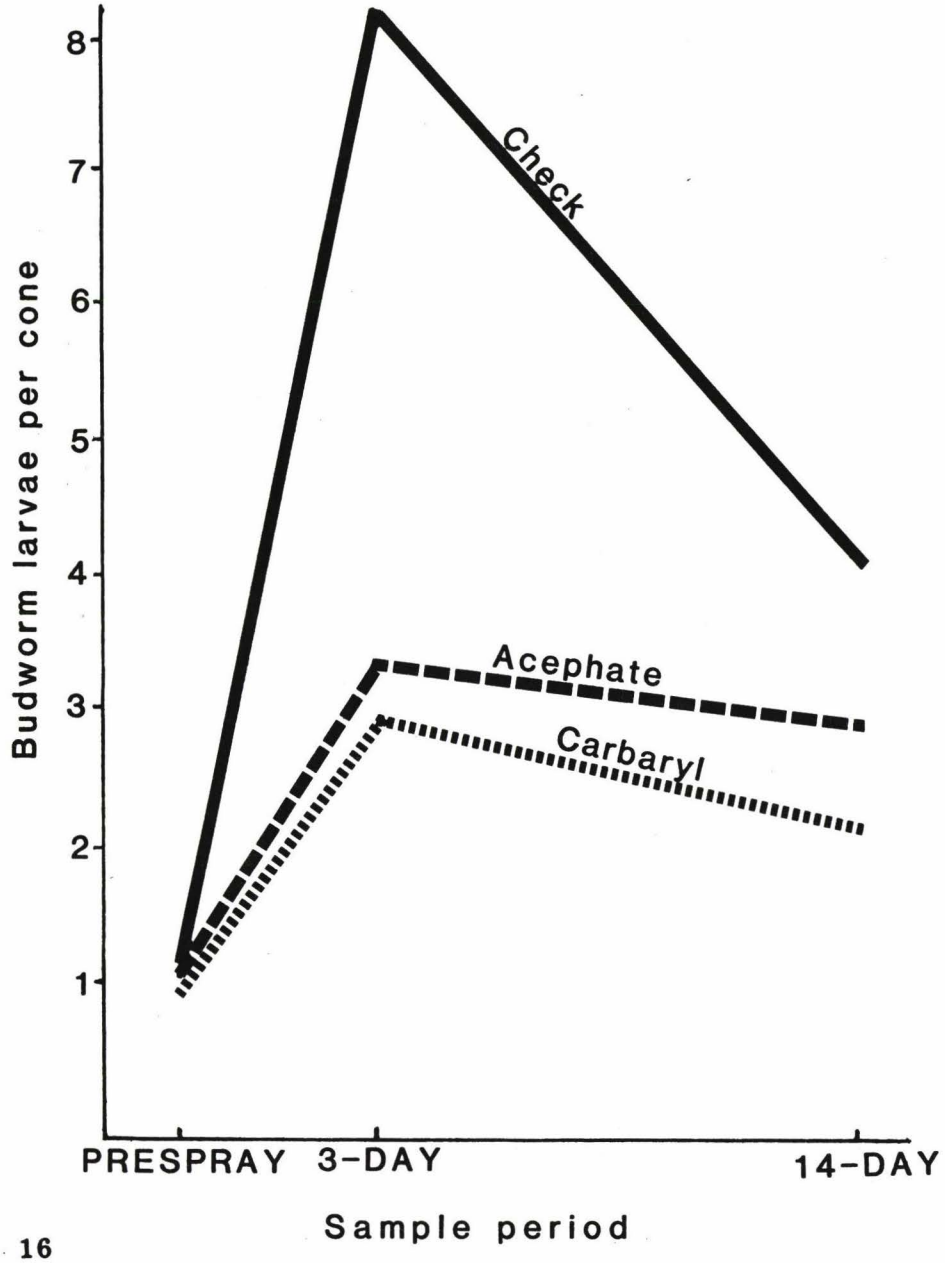
APPENDIX

Appendix 1. Budworm dispersal trend of stage two larvae at Lubrecht Experiment Forest, 1979 (unpublished data courtesy David G. Fellin).

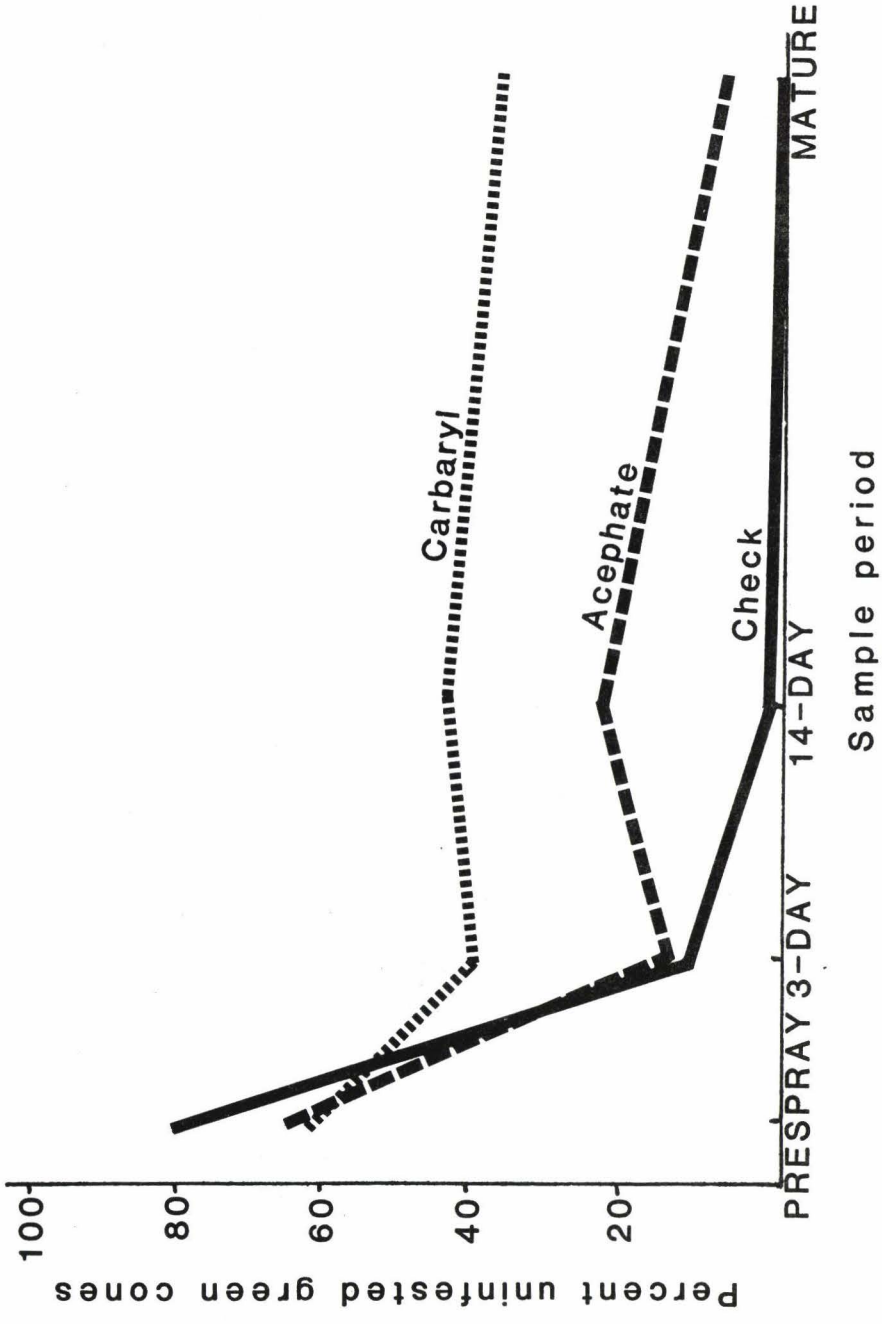


Appendix 2.

Number of budworm larvae per cone by sampling period from Lubrecht Experiment Forest, 1979.



Appendix 3. Percent uninfested green cones by sampling period from Lubrecht Experiment Forest, 1979.



APPENDIX 4

Number of cones collected per sample period from Lubrecht Experimental Forest, 1979.

	TREE #	PRESPRAY	3-DAY	14-DAY	MATURE	TOTAL/TREE
ACEPHATE	1	20	24	30	32	106
	2	24	28	25	28	105
	3	17	16	12	9*	54
	4	12	12	12	9*	45
	5	21	49	65	23	158
	6	25	21	29	10	85
	7	11	10	10	11	42
	8	13	17	29	18	77
	9	11	15	47	46	119
	10	6*	10	7*	12	35
	TOTAL	160	202	266	198	826
CARBARYL	1	11	16	21	56	104
	2	12	11	12	11	46
	3	10	11	12	10	43
	4	10	19	26	6*	61
	5	10	14	14	50	88
	6	26	32	27	38	123
	7	35	20	17	26	98
	8	31	19	42	50	142
	9	16	46	10	79	151
	10	11	12	11	13	47
	TOTAL	172	200	192	339	903
CHECK	1	12	21	25	11	69
	2	11	10	6*	0*	27
	3	21	13	22	28	84
	4	11	10	15	0*	36
	5	10	11	11	17	49
	6	19	11	11	49	90
	7	12	14	9*	23	58
	8	22	12	23	26	83
	9	38	40	25	1*	104
	10	21	20	29	25	95
	TOTAL	177	162	176	180	695

* On these samples we were unable to collect the required 10 cones per tree.

APPENDIX 5

Cone condition by sampling period and treatment from Lubrecht Experimental Forest, 1979.

	Sampling Period	Dead Buds(%)	Infested Dead(%)	Infested Green(%)	Unifested Green(%)
ACEPHATE	Pre	3.1	-	32.5	64.4
	3-Day	7.9	43.1	34.6	14.4
	14-Day	0.8	50.0	26.3	22.0
	Mature	-	22.7	70.7	6.6
CARBARYL	Pre	2.3	-	34.0	62.8
	3-Day	0	32.0	28.5	39.5
	14-Day	2.1	39.1	17.2	41.6
	Mature	-	16.5	48.4	35.1
CHECK	Pre	0.6	-	19.2	80.2
	3-Day	0	45.1	43.2	11.7
	14-Day	0	82.4	16.5	1.1
	Mature	-	93.3	6.7	0

APPENDIX 6

Visual cone damage and seed production per cone and treatment from Lubrecht Experimental Forest, 1979.

Tree No.	Visual Damage (%)			Total Seed Per Cone		
	Ace-phate	Carba-ryl	Check	Ace-phate	Carba-ryl	Check
1	33.8	12.0	100	12.1	10.6	0
2	100	100	-	.5	0	0
3	86.1	46.6	100	3.0	18.1	0
4	82.3	66.4	-	.4	5.5	0
5	38.5	18.0	100	7.6	18.2	0
6	54.5	6.0	100	5.6	22.9	0
7	71.4	100	100	2.8	0	0
8	45.1	34.7	100	7.4	14.2	0
9	58.1	9.7	100	8.4	27.7	0
10	97.6	31.4	100	0	9.2	0
Mean	66.7	42.5	100	4.8	12.6	0

This report describes project results involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife--if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

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